

# TWO-SIDED MARKETS, COMPETITION AND EXCLUSIONARY PRACTICES

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**Abstract**

Markets, where two, or more, groups of agents encounter via intermediary platform and there are network externalities between those groups, can be called two-sided markets. Functioning and key characteristics of two-sided markets are described in this bachelor thesis by presenting three models of initial settings of two-sided markets provided by Armstrong (2006). As Armstrong (2006) suggests the role of i) relative size of cross-group externalities, ii) charging format and iii) agents homing decisions, whether they choose to join a single platform (single-homing) or to join multiple platforms (multi-home) turn out to be crucial in determining market outcomes.

There are some limitations in models. Some modifications to account those limitations can be done more easily than others. Right format of charges and costs for platform are clearly case specific. In addition, nonnegativity constraint of prices, fixed costs and agents' investment cost of joining platform may be considered to be included case by case. More complex questions arise, when source of agents' decisions about single-homing and multi-homing and source of platforms' differentiation decisions are considered. Unambiguous answers to these questions may not be reached just by some little modification of parameters. One complex issue is related to feasibility of crucial assumption in competitive bottleneck model, where agents are 'atomistic' and do not have market power to affect other group's decisions by their own decisions. Most importantly it turns out that the format used for determining utility and agent heterogeneity within model are crucial factors in two-sided market models having implications also for endogeneity of agents' decisions about joining single or multiple platforms.

From competition policy point of view, it is useful to pay attention to exclusionary practices, which platforms may have incentive to use to reach dominant position. Existing literature suggests a bit different approaches for assessment of dominance in the context of two-sided markets. Predatory pricing seems even more complicated to detect than in one-sided markets because in two-sided markets price on one side do not reflect only costs incurred from that side but also relative cross-group externalities between groups. Exclusive contracts set by platforms to persuade agents to abandon rival platform may turn around the way, in which total surplus is shared between groups of agents and platform.

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**Keywords** two-sided markets, platform competition, exclusionary practices

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# 1. Introduction to two-sided markets

This bachelor thesis examines two-sided markets, competition in such settings and exclusionary practices. There are several market intermediaries, or platforms as I will call them, which facilitate interaction between two, or more, groups of agents. These kinds of settings can be called two-sided markets, when those two distinct groups are interested in the number of agents in other group(s) taking part to platform. Two-sided markets are relatively new topic in academic literature of economics. First seminal papers on two-sided markets were published in early 2000s. Traditional examples of two-sided markets pointed out by Armstrong (2006) are for example shopping malls, which try to attract both consumers and businesses, and newspapers, which provide two distinct services for two groups, namely readers and advertisers. Early examples were also Yellow pages telephone number directories, which were distributed to consumers free-of-charge and advertisers were then charged more to enable that free distribution to consumers. For more detailed analysis about Yellow pages directories, see Rysman (2004). Credit card market is one example of two-sided markets where consumers are interested in how many merchants will accept some particular card and merchants are interested that how many customers would use some card they consider accepting. For analysis applicable in credit card markets, see Rochet and Tirole (2003). Another one of early papers on two-sided markets is Caillaud and Jullien (2003), which examines equilibrium market structures in context of competition between online informational intermediaries, which services are related to online search, certification, advertising and price discovery.

Few additional examples that are relevant to mention in the context of two-sided markets are after table 1 in Rochet and Tirole (2003, p. 993) gaming platforms, operating systems, affiliation services, charge-free TV networks and real estate agents. There are several examples of businesses which build on characteristics of two-sided markets. Such characteristics in broad manner are presence of at least two distinct groups taking part to market, platform which facilitates interaction between these groups and network effects between these groups, to say that agents within groups are interested in the number of agents in the other group(s). However, it seems that analyses are quite industry or case specific and that there are many determinants having effects on the possible market outcomes, and this will be discussed in more detail in the following chapters.

Two-sided markets differ from traditional one-sided markets. Prices determined by platform are not associated only with the group, that charge is imposed to, but also by the other group on the platform and how benefits of interaction are shared between these groups. When parties are interested in the number of agents in the other group(s), there may be concern that eventually such markets tip towards single dominant platform. Therefore, it seems suitable to give some time to discuss what kind of exclusionary practices platforms might use to get in that dominant position or maintain such position and how such practices should be interpreted in context of two-sided markets. I will discuss this more detail in the end of the thesis.

This thesis continues as following. First, I discuss about two-sided markets in general and how they have been defined in earlier literature. Second, I introduce and explain how three models, provided by Armstrong (2006), address two-sided markets and what assumptions they involve. Third, I provide some conclusion about those three models and explain what essential characteristics of two-sided markets they describe. I also discuss about some limitations of the models. After that, I continue to discuss the issues of two-sided markets from competition policy point of view. In this area main focus is put on the problems in assessing dominance and two forms of exclusionary practices, namely predatory pricing and exclusive dealing. In the end of this thesis I present short conclusion with ideas for future research.

## 2. Defining two-sided markets

Literature on two-sided markets indicates that two-sided markets as phenomenon is closely related to network effects and in particular to indirect network effects. According to Rysman (2009), the main distinction between literature on two-sided markets and literature on network effects is the central role of market intermediaries. According to Rysman (2009), network effects or externalities refer to situation where value of product for one consumer depends on the number of other consumers that purchase the same product, whereas indirect network effects arise, when value of a product for one depends on the availability and/or quality of some complementary product.

Indirect network effects were addressed by Katz and Shapiro (1985) in the context of hardware and software. They noted that, Hardware's value is positively affected by availability of compatible software and software developers interest to develop software, compatible with some particular hardware, depends positively on the amount of that hardware is purchased. Katz and Shapiro (1985) also pointed out that this *hardware-software paradigm* applies in other contexts as well and mentioned for example video games, which has been later researched also in context of two-sided markets. For empirical analysis about video game industry, see for example Lee (2013). In the context of two-sided markets, externalities lay between two distinct groups and are closely related to idea behind *hardware-software paradigm*, but instead of using term indirect network externalities to describe that special relation between distinct groups, many other terms are often used. In this thesis I will be consistent with terminology used by Armstrong (2006) and I use "*cross-group externalities*" to refer to relation between agents in distinct groups. In addition, I use "*intra-group externalities*" when referring to agent's relations with other agents within the same group.

In broad manner, Rysman (2009) defines two-sided markets to be markets where two or more distinct groups of agents interact with each other via platform, which facilitates this interaction and externalities between those groups exist. These cross-group externalities are in the core of understanding two-sided markets. Armstrong (2006) points out that there are cases, where we could consider two distinct groups of agents in interaction, but no cross-group externalities exist. Value created in the interaction of market participants and the cross-group externalities can be either positive or negative, and eventually these are important factors to consider, when intermediary chooses how it serves and charges different groups of agents in the two-sided market.

Rochet and Tirole (2006, p.646) define two-sided markets as following "*the volume of transactions between end-users depends on the structure and not only on the overall level of the fees charged by the platform*". However, it is not straightforward how two-sided markets should be defined and Rysman (2009) noted that two-sided markets could be considered just as a set of strategies because it is often intermediary's choice alone whether it chooses to serve and charge two distinct groups or not. More importantly, Rysman (2009) emphasizes that relevant question is not necessarily the technical definition of two-side markets but that how relevant two-sided issues are in determining outcomes in some specific context. Clearly, this point of view emphasizes the relevance of both cross-group externalities and existence of platform facilitating interaction between agents. On the other hand, definition by Rochet and Tirole (2006) underlines well that distinct groups of agents are not able to negotiate cross-group externalities away and platform, when maximizing its profit, takes this account and chooses optimal pricing structure, rather than just optimal overall level of prices.

Based on earlier literature, Weyl (2010) lists three main features which existence seem to raise relevance of two-sided issues. First, existence of a platform providing distinct services to two sides of the market, which can be explicitly charged different prices. Second, existence of cross-group externalities. Third, platforms are price setters on both sides of the market.

### 3. Pricing decisions in monopoly, single-homing and multi-homing

The questions addressed in the following three models by Armstrong (2006) are: how optimal price structure for two groups is determined, what would be welfare maximizing structuring of these prices and how equilibrium outcome in two-sided markets is affected by format of pricing. Question in pricing format is that whether two groups of agents are charged based on access to market, activity in the market or some combination of these. First model (Monopoly model) describes monopoly platform. Second model (Single-homing) is one of competing platforms, where agents can only take part to one of two platforms at the time. When agent takes part to only one platform at a time, it is called single-homing. Third model (Competitive bottlenecks) considers platforms, where agents on the other side are able to take part to both platforms simultaneously, if they wish so. When agents take part to more than one platform at a time, it is called multi-homing. All models consider charges as pure access fees, but Single-homing and Competitive bottlenecks models are also modified for two-part tariffs which emphasizes the differences in outcomes due to format of charges. Three models aim to describe effects on market outcomes by three key determinants such relative size of cross-group externalities between groups, charging format and presence of multi-homing (Armstrong, 2006).

Set of assumptions varies a bit between all three models in Armstrong (2006). All models leave intra-group externalities mainly out of consideration. Intra-group externalities refer to fact that agents might be directly interested also on number of agents within the same group in positive or negative manner. Until the third model, it is assumed that agents consider additional agents in the other group equally valuable for themselves. This means that agents within groups are assumed to be in this sense quite homogenous. This assumption simplifies analysis and question about agents' homogeneity and heterogeneity within groups may be quite case-specific. In some cases, it may be that platform just attracts certain type of agents or that platform decides not to be open to join for all agents. Two first models allow existence of some kind of fixed benefit that agents receive just by joining a platform regardless of the number of agents in the other group. Third model assumes that no fixed benefit exists but relaxes assumption about how valuable agents consider additional agents in the other group. These two approaches represent two alternative sources of agent heterogeneity to use in two-sided markets models. In addition, latter two models consider single-homing and multi-homing as exogenous phenomena.

Even though Armstrong (2006) consider the fixed benefit to vary on platform and agent basis in Monopoly and Single-homing model, it does not have much effect analyses in the context of monopoly model. In Single-homing model it is not included in formulas since, it can be assumed to be distributed among agents in a manner that allows symmetric equilibrium analysis.

#### 3.1. Monopoly model

Following will describe monopoly platform model presented by Armstrong (2006, p. 671-673). Platform serves two distinct groups denoted 1 and 2. Surpluses for participants in groups are denoted as following.

$$\text{Group 1: } u_1 = \alpha_1 n_2 - p_1 \quad \text{Group 2: } u_2 = \alpha_2 n_1 - p_2$$

Where  $\alpha$  is a parameter describing the strength of the cross-group externality,  $n$  is number of participants, here number of participants on the other side of platform and  $p$  is the price of participation, access fee. Number of users,  $n$  in one group is increasing function  $\phi(u)$  of that group's utility, so  $n_1 = \phi_1(u_1)$ . For platform, cost of serving participant from group 1 is  $f_1$  and from group

2  $f_2$ . Model considers platform offering utilities for participants rather than prices and price is therefore got implicitly from utility function as following  $p_1 = \alpha_1 \phi_2(u_2) - u_1$ . Platform's profit function for serving these two distinct groups of agents is then given simply as sum of both side's profits, which are number of participants times price-cost margin.

$$(1) \pi = [\alpha_1 \phi_2(u_2) - u_1 - f_1] \phi_1(u_1) + [\alpha_2 \phi_1(u_1) - u_2 - f_2] \phi_2(u_2)$$

Aggregate consumer surplus of group 1 participants is some increasing function  $v_1(u_1)$ . Aggregate consumer surplus can be thought to be product of number of participants and surplus of one participant if fixed benefit does not exist or on aggregate level equals 0. This is because agents are assumed to give an equal amount of value for each participant on the other side relative to other agents within their group and no price discrimination is allowed to occur within model. Then  $v_1(n_1, u_1) = n_1 u_1$  and with envelope theorem we can compute following:

$$(2) \frac{d}{du_1} v(\phi_1^*(u_1); u_1) = \frac{\partial v}{\partial u_1}(\phi_1^*(u_1); u_1) = n_1$$

Envelope theorem explains why  $v_1'(u_1) \equiv \phi_1(u_1)$  holds. Welfare maximizing utilities can be derived with first order conditions from sum of platform profit and aggregate surpluses for both groups,  $W = \pi + v_1(u_1) + v_2(u_2)$ . Welfare maximizing utility for group 1 is given with first order conditions  $u_1 = (\alpha_1 + \alpha_2) \phi_2(u_2) - f_1$  and this utility satisfying price (3) for group 1 participants is then given implicitly from  $p_1 = \alpha_1 \phi_2(u_2) - u_1$ . When platform maximizes only its profit, optimal price is given as in (4).

$$(3) p_1 = f_1 - \alpha_2 \phi_2(u_2)$$

$$(4) p_1 = f_1 - \alpha_2 \phi_2(u_2) + \frac{\phi_1(u_1)}{\phi_1'(u_1)}$$

Note that these apply to group 2 as well, only lower indices are changed. Monopoly model by Armstrong (2006) suggests that access fee for agents, charged by the platform, should be set below the cost of serving them in order to maximize welfare if that group raises positive cross-group externalities to another group. If platform's profit alone is maximized, access fees derive up from the welfare maximizing level of fees by a parameter related to inverse elasticity of participation. This is demonstrated by applying traditional Lerner index (5). Platform faces elasticity of participation (6) and when equation (4), profit maximizing price, is rearranged and divided by  $p_1$ , special Lerner index (7) can be given. Lerner index was introduced by Lerner (1933) in paper discussing about appropriate way to examine the degree of monopoly power in market.

$$(5) \frac{P-MC}{P} = \frac{1}{\eta}$$

$$(6) \eta_1(p_1|n_2) = \frac{p_1 \phi_1'(\alpha_1 n_2 - p_1)}{\phi_1(\alpha_1 n_2 - p_1)}$$

$$(7) \frac{p_1 - [f_1 - \alpha_2 \phi_2(u_2)]}{p_1} = \frac{\phi_1(u_1)}{p_1 \phi_1'(u_1)}$$

Lerner index requires that, price and output are set to maximize profit so, marginal revenue needs to equal marginal cost (Lerner, 1933). Later, when discussing assessment of dominance, foundation of Lerner formula and Lerner index in context of two-sided markets will be discussed. Profit-maximizing prices generated in the model implicate that it can be optimal for platform to subsidize other group if that group's elasticity of participation is large simultaneously with positive cross-group externality to another group, or if that cross-group externality is high. Armstrong (2006) points out that there is no reason why one group's large elasticity of participation together with positive cross-group network externality for another group couldn't affect simultaneously so much that the price is

optimal to set negative. There are not many examples, where charging format for both sides is access or access fee but Armstrong (2006) suggests that this model could be applied in the context of traditional yellow pages directories, where advertisers are charged for placing advertisement in directory and directories are given for telephone subscribers for free. However, yellow pages directories aren't necessarily very useful example to consider in today's context and their online substitutes differ quite fundamentally from them.

One other context for applying this kind of model might be trade fairs, where firms represent their products or services for consumers or other firms. *Slush* could be considered as one of this kind of fairs.

Attendees consist mainly from start-ups, investors and individual attendees. These groups are interested in each other's presence in event. *Slush* seem to be concerned about quality of joining start-ups and investors because they require application from them, but this doesn't mean that they are homogenous in a way that participants in other groups value presence of all start-ups, or investors, equally. *Slush* sets to individual attendees higher fees compared to start-ups. Also, angel investors are subsidized compared to other investors. Most of the profit seem to be extracted from individual attendees while they are largest participant group and are also charged most. The relative charges between groups here, are just discussion because, *Slush* seem to be using dynamic pricing since prices had changed on their website notably between my visits. (*Slush*, 2019)

Clearly, there are some characteristics of two-sided markets present but this model does not directly apply in the context of *Slush* for couple reasons. There are more than two distinct groups of agents. Model could be further developed to address more than just two groups of agents. Probably, assumption regarding agents' preferences about agents in the other groups, should be relaxed as well. Evaluating that do this kind of fairs have monopoly is another question, which is needed for understanding platforms' decisions in this context. More broadly, 'Social gatherings', where one group of agents, for example group of celebrities, are subsidized to join and other participants are charged, mentioned in table 1 of Rochet and Tirole (2003, p. 993) could be one possible context to apply this model.

### 3.2. Single-homing

Following will describe single-homing model provided by Armstrong (2006, p.673-677). Single-homing model of competing platforms describes context, where agents on both sides can take part only to one platform at the time. Single-homing is fully exogenous here and therefore applicability of model may be limited. On the other hand, it is relevant question that why some agents would be interested to take part in the both platforms simultaneously. Since no intra-group externalities are assumed to exist, reason need to lay in cross-group externalities or in fixed benefit received regardless of the number of agents on the other side. When no fixed benefits exist, agents decide to multi-home only if they are willing to pay an additional access fee for other platform to get interact with all agents on the other side. Inexistence of fixed benefit from joining a platform may be considered reasonable because if that kind of utility actually existed largely relative to cross-group externalities, then two-sided issues might not be so relevant in determining market outcomes. Inexistence of intra-group externalities problematic nature of utility determination in two-sided markets will be stressed more detail later. Regardless of the exogenous single-homing, model describes well other things such effects of charging formats and acts as first step to understand competition of platforms.

Hotelling model is used to determine market shares of two competing platforms. Hotelling (1929) presented model to describe competition stability in case of duopoly. Hotelling model contains Hotelling line which is interval between 0 and 1. Relying on (Lipczynski, Wilson, Goddard 2009,



p.394-403) I consider format of Hotelling model used in Armstrong (2006) to be such, where price, or surpluses here, are endogenously determined and locations of firms are fixed in each endpoint of the line. More specifically, I consider the format to be a non-collusive, where firms choose their prices to maximize their profit given prices set by their rival. What makes agents within groups different from each other, is their location. Agents incur transport costs to do business with each platform depending on their distance from the closest platform. This transport cost is product of transport cost parameter  $t$  and agent's distance to closest platform. This location with the transport cost can be interpreted in other dimensions such product differentiation for example. Here these differentiation parameters describe the fact that agents' cost of switching to another platform is higher when the level of differentiation is high. In Armstrong (2006), these differentiation -parameters  $t_1$  and  $t_2$  may differ between groups even though within model, platforms necessarily don't have such incentive to differentiate less or more on one side compared to other. The model takes these differentiation parameters exogenous. Essential assumption in the Hotelling model is that market is fully covered, so each agent chooses one or another platform. This requires that agents in midway of line having distance 0,5 to both platforms do not receive negative surplus from taking part to one platform. Next, I present Single-homing model with pure access fees.

Share of agents in the group 1 taking part to platform 1 is determined as following. Upper indeces refer now to the platforms 1 and 2. Surplus for agents from joining platform 1 is  $u_1^1 - t_1(n^1)^2$ , where  $n^1$  is their distance to platform 1. Surplus for agent from joining platform 2 is  $u_1^2 - t_1(1 - n^1)^2$  because market is assumed to be fully covered, which means that  $n^2 = 1 - n^1$  holds. Then these can be set equal and  $n^1$  can be solved as in (8) and then utilities can be inserted as a function of prices and externality parameters, as in (9). Functions in (9) can be solved simultaneously and then market shares are given as in (10).

$$(8) \quad n^1 = \frac{1}{2} + \frac{u_1^1 - u_1^2}{2t_1}$$

$$(9) \quad \text{Group 1: } n_1^1 = \frac{1}{2} + \frac{\alpha_1(n_2^1 - 1) - (p_1^1 - p_1^2)}{2t_1} \quad \text{Group 2: } n_2^1 = \frac{1}{2} + \frac{\alpha_2(n_1^1 - 1) - (p_2^1 - p_2^2)}{2t_2}$$

$$(10) \quad \text{Group 1: } n_1^1 = \frac{1}{2} + \frac{1}{2} \frac{\alpha_1(p_2^2 - p_2^1) - t_2(p_1^2 - p_1^1)}{t_1 t_2 - \alpha_1 \alpha_2} \quad \text{Group 2: } n_2^1 = \frac{1}{2} + \frac{1}{2} \frac{\alpha_2(p_1^2 - p_1^1) - t_1(p_2^2 - p_2^1)}{t_1 t_2 - \alpha_1 \alpha_2}$$

Profit function for platform 1 (11) is again formed simply as sum of profits from each side of platform.

$$(11) \quad \pi^1 = (p_1^1 - f_1) \left[ \frac{1}{2} + \frac{1}{2} \frac{\alpha_1(p_2^2 - p_2^1) - t_2(p_1^2 - p_1^1)}{t_1 t_2 - \alpha_1 \alpha_2} \right] + (p_2^1 - f_2) \left[ \frac{1}{2} + \frac{1}{2} \frac{\alpha_2(p_1^2 - p_1^1) - t_1(p_2^2 - p_2^1)}{t_1 t_2 - \alpha_1 \alpha_2} \right]$$

Armstrong (2006) emphasizes that additional condition (12) is needed to describe sizes of differentiation parameters relative to parameters describing the strength of cross-group network externalities. It comes from second order conditions of profit maximization problem. More precisely, it is condition which needs to hold for Hessian  $D^2 \pi^1(\mathbf{p}^*)$  to be negative definite. Another requirement is that  $t_1 t_2 - \alpha_1 \alpha_2 > 0$ , which follows from the same condition. Otherwise, resulting outcome will be that in the market of two-sided platforms there will be only one platform where every agent wants to take part and no symmetric equilibrium exist.

$$(12) \quad 4t_1 t_2 > (\alpha_1 + \alpha_2)^2$$

Equation (12) contains some information regarding the possible combination of externalities. We can see that, when differentiator parameters are hold constant, settings, where cross-group externalities to both directions are large, are more in risk to violate condition (12) compared to cases, when cross-group externalities are positive to one direction and negative to other. Prices set by platforms are derived from platforms' reaction functions to rival's prices. This reaction function for platform 1 is

given by first order conditions of function (11). Armstrong (2006) notes that profit functions are quadratic and concave in prices. In symmetric equilibrium, both platforms set prices as in (13).

$$(13) \quad p_1 = f_1 + t_1 - \frac{\alpha_2}{t_2}(\alpha_1 + p_2 - f_2) \quad p_2 = f_2 + t_2 - \frac{\alpha_1}{t_1}(\alpha_2 + p_1 - f_1)$$

$$(14) \quad \frac{\alpha_2}{t_2}(\alpha_1 + p_2 - f_2)$$

Armstrong (2006) notes that, equilibrium price for group 1 is now adjusted downwards by factor (14) compared to case where no cross-group externalities exist ( $\alpha_1, \alpha_2 = 0$ ). This imply that positive cross-group externalities tend to increase competition, at least in this Hotelling specification.

Armstrong (2006) suggests that term  $(\alpha_1 + p_2 - f_2)$  represents benefit, which platform receives from its each extra group 2 agent. This is because  $\alpha_1$  describes benefit from one additional group 2 agent to agents in the group 1 and platform can extract this extra benefit from agents in the group 1. According to him, the latter two represents just marginal revenue received from extra group 2 agents. He notes that, factor  $\frac{\alpha_2}{t_2}$  represents how many extra group 2 agents will join platform when one extra group 1 agent joins platform and this can be seen from latter equation in (9), when prices for group 2 are kept constant and extra group 1 agent is attracted. He concludes, when these two factors are combined to (14), factor can be interpreted to describe benefit that platform receives from group 2 when it attracts one extra group 1 customer.

Solving simultaneously equations in (13) gives us equilibrium prices in simpler format (15) and then profit, that each platform makes, can be simplified to (16).

$$(15) \quad p_1 = f_1 + t_1 - \alpha_2 \quad p_2 = f_2 + t_2 - \alpha_1$$

Differentiation parameter  $t$  describes the competitiveness of the market on its side and resulting profit maximizing prices in symmetric equilibrium are determined in a manner that price-cost margin for one group equals to differentiator parameter on that side of market minus the externality for other side of the platform (Armstrong, 2006). Thus, in this kind of setting platform will receive smaller price cost margin from the side, which is more competitive, which means that differentiation parameter is lower, or which raises larger externalities to the other side compared to externalities received from that other side.

One can think that if agents experience high cost of switching to competing platform, then, all else equal, platform can extract more money from them compared to case, where switching cost is low. Also, if the externalities raised by agents on one side compared to other side are relatively low, that group is not needed to subsidize as much, to attract more agents to the other side. It is also possible that price is set for one side below cost of serving them because differentiation parameters are always nonnegative and sum of externality strength parameters can be near zero, or zero. So, the larger the externalities are, positive and negative one, the more price can be below cost of serving agents according.

$$(16) \quad \pi = \frac{t_1 + t_2 - \alpha_1 - \alpha_2}{2}$$

Profit (16) that each platform makes in the symmetric equilibrium is increasing in differentiation parameters but decreasing in the parameters describing strength of cross group network externalities. In this setting positive cross group externalities tend to decrease platforms' profit, which doesn't seem straightforward, but Armstrong (2006) explains tendency of externalities to decrease platforms' profits by stating that externalities act as an additional reason for platforms to compete from agents.

These competition increasing effects also implied by factor (14) adjusts equilibrium price for group 1 down if positive cross-group externalities from group 1 to group 2 exist. Next, I present results, when Single-homing model is modified for two-part tariffs.

Two-part tariffs consider case where platform sets for group 1 first fixed access fee  $p_1^1$  and then charges some fixed fee  $y_1^1$  per every agent joining platform from the group 2. Now surplus for group 1 participant is  $u_1^1 = (a_1 - y_1^1)n_2^1 - p_1^1$ . Interestingly, relative to case, where only access fees were used, profit for each platform (17) increases by a factor related to per-agent charges. Armstrong (2006) suggests that the reason is that per-agent charges reduce indirect network externalities which lead platforms to compete over agents so fiercely in the first place.

$$(17) \quad \pi = \frac{t_1 + t_2 - \alpha_1 - \alpha_2}{2} + \frac{y_1 + y_2}{4}$$

This is easier to understand when two extreme cases of pure access fee and pure charge-per-agent are compared. When these two cases are compared, Armstrong (2006) points out that in case of fully per-agent-charges platform commits to provide constant utility to agents. In the case of access fees platform can be considered to commit to attract certain number of agents to the other group. Moreover, when access fees are considered, agents are interested in the number of agents on the other side and in the strength of externalities they will receive from the other side. They benefit from each additional agent joining the platform from other side of the platform. In the other extreme case, when fully per-agent-charges, where the charge equals to cross-group externality received from other side, are considered, no such effect exists because  $(a_1 - y_1^1) = 0$  and therefore agent receives 0 net utility from each extra agent on the other side.

Social welfare analysis in the context of two-part tariffs is complicated. On the one hand, if competing platforms are able to coordinate high per agent charges even so large that they override inter-group network externalities fully, then they will receive high profits but at the same time they extract more of the surpluses of agents (Armstrong, 2006). However, analysis considering some sets of two-part tariffs between pure access fees and pure per agent charges is complicated and results are hard to draw since no single symmetric equilibrium exists but continuum of symmetric equilibria and even asymmetric equilibria (Armstrong, 2006).

### 3.3. Competitive bottlenecks

Competitive bottlenecks model presented by Armstrong (2006, p.677-686) will be discussed in general in this chapter. Specific cases regarding supermarkets media and advertised-supported are discussed later in this chapter. For more detailed analysis and formulas see section 5 in Armstrong (2006). Competitive bottlenecks model considers case, where agents on one side are able to multi-home while agents on the other side single-home. Name of the model refers to its main outcome that there will be less agents on the multi-homing side compared to case where both sides single-home. Multi-homing and single-homing are exogenous here though multi-homing refers to the fact that agents on the multi-homing side must be ready to pay additional price for being able to interact with all agents on the other side of platform. But no further analysis about agents' decisions on whether to multi-home or single-home aren't provided. Model contains assumption that requires that agents' decision on the multi-homing side, whether they decide to join only one platform or both platforms, do not affect decisions of agents on the other side. This is done by assuming that agents on the multi-homing side have no such market power that their decisions to join only one platform would draw large number of single-homing agents to that same platform. Closely related to this, model assumes that decisions about joining one platform on the multi-homing side are independent from the decision to join another platform. The importance of noting these assumptions is that, in Single-homing model,

possibility of multi-homing didn't exist, and this model builds on that assumption of independent joining decisions on the multi-homing side. This model relaxes assumption regarding how agents give value for additional agents on the other side. This is needed for ensuring that agents on the multi-homing side face decision about whether their profit from joining platforms is nonnegative. Armstrong (2006) mentions among all newspapers, supermarkets and shopping malls as prominent frameworks to apply this kind of the model. Businesses are assumed to be on the multi-homing side and consumers on the single-homing side for some exogenous reasons.

The model assumes that agents on the multi-homing side are heterogeneous and they all have monopoly position with their product relative to other agents in the multi-homing side. Starting point of developing the model is the fact that agents on the multi-homing side are interested to interact with all the agents in the single-homing side and that they are ready to pay for it. Platforms are assumed to determine how many multi-homing agents and with which price they serve given their market share of agents on the single-homing side. Price they charge from multi-homing agents is tool for them to determine the number of multi-homing agents given their market share of single-homing agents. The main result of the model is that there might be too few agents present in the multi-homing side compared to what would be socially optimal (Armstrong, 2006). This follows from the fact that each platform holds a monopoly position of single-homing agents on their platform and this allows them to charge excessive prices from agents on the multi-homing side. However, there might not be such market failure that too few multi-homing agents take part to platform if assumption regarding heterogeneous agents on the multi-homing side was relaxed (Armstrong, 2006). If multi-homing agents competed against each other, then they might be better off with fewer participants on their side. Excessive pricing exercised by platforms on the multi-homing side does not directly indicate that platforms make excessive profits (Armstrong, 2006). Platforms may face so fierce competition of agents on the single-homing side that they need to use taxation from multi-homing side to subsidize agents on the single-homing side.

Competitive bottleneck model in Armstrong (2006) is addressed in the context of supermarkets, which act as a platform between consumers and suppliers, and in the context of shopping malls, which act as platforms between consumers and retailers. Still no competition is assumed to appear on suppliers' side and each supplier is interpreted to be in monopoly position with their product. Suppliers do not have any preferences between platforms and the only variable they are interested in is the number of consumers on the other side. The model considers access fees only and it is constructed to emphasize that in equilibrium platforms, supermarkets here, provide some particular level of utility for consumers on the single-homing side. Consumers utility is simply given by number of available products multiplied by the net surplus per product. Given that level of utility and number of consumers on platform, platform chooses the number of suppliers it wants to attract. This kind of modelling leads to situation, where price for suppliers is again chosen to satisfy the optimal number of retailers regarding platform's and consumers' best interest. Similar kind of market failure is present in sense that too few products will be present in the supermarket. This market failure follows from that platforms completely ignore suppliers' interest, when choosing optimal number of suppliers to join, and model assumes that retailers are monopolists which imply that aggregate surplus of retailers is increasing in their number on platform (Armstrong, 2006). Since, platforms do not have any incentive to compete over suppliers in the multi-homing side they will compete on consumers side. Relative surpluses for platforms and consumers depend on the competitiveness of consumers' side (Armstrong, 2006).

Following will consider Competitive bottleneck model in the context of advertised-supported media. This model of Armstrong (2006) applies in the context of advertise supported media such newspapers and it introduces both extreme cases of charges set to multi-homing side agents, access fees and fully per agent charges. Still, no competition is expected to be present among advertisers, who are able to

multi-home. However, the assumption regarding how agents give value for agents present in the other side of platform is relaxed. Advertisers payoff is assumed to be linear in the number of consumers who sees it, and this may be reasonable when no intra-group externalities are assumed to exist, or possibility of advertisers' limited supply is ignored (Armstrong, 2006). In the other words, if intra-group externalities existed on single-homing side, positive or negative, then there would be some additional factor affecting to consumers' purchase behavior.

In terms of social welfare there are too few ads on the platform in equilibrium. Optimal prices for consumers in equilibrium depends on the format of charges on the retailer side. While optimal price for consumers depends on the way retailers are charged, there are no effects on quantity of ads or welfare of advertisers (Armstrong, 2006). This implies that the only effect is on, how surplus is divided between consumers and platform. When advertisers are charged only for access and consumers benefit from ads, it seems that platform profits are lower, and consumers receive greater surplus compared to case where advertisers are charged on per consumer basis (Armstrong, 2006). If consumers receive negative benefit from each ad, then charging advertisers only for entry turns higher relative surplus for platform compared to consumers (Armstrong, 2006). This demonstrates how charging format on other side of platform has effects on profits made on other side. Moreover, according to model it is possible with either case of charges that consumers on the single-homing side are heavily subsidized, even to the extent where price for them is negative (Armstrong, 2006).

## 4. Key characteristics of models and limitations

Models consider two-sided markets in quite general way and the fundamental subject of matter addressed are that cross-group externalities tend to increase competition between platforms and that the format of charges chosen by platforms affects the strength of those externalities. Single-homing model demonstrates well that platforms can use format of charges as a strategic tool to reduce competition. This is even possible by changing charging format only for one side of platform as in competitive bottlenecks model, where charging format on multi-homing side, given the sign of cross-group externalities from multi-homing side, affected how the surplus was divided between platform and single-homing agents. When social welfare is considered, we see that, when strong positive cross-group externalities are present and they are not tried to cut by platforms, agents receive relatively more from total surplus compared to case where platforms cut those cross-group externalities by two-part tariffs or per agent charges. If multi-homing is allowed to occur, then platforms' competition of agents in the multi-homing side is cut down and platforms compete over agents in the single-homing side. Moreover, all models emphasize the effects of cross-group externalities since utilities are defined only via them.

It is important to note that, while focus in this thesis is on platform's pricing decisions and competition, there are many other factors as well such openness, quality and innovation investments to consider when examining competition in two-sided markets. For these other factors, see for example Rysman (2009).

There are limitations in models and clearly, they do not apply to all two-sided markets as well as to others. Even though the models describe essential characteristic of two-sided markets well, some industry specific questions may be answered better by introducing some modifications to the models. Here are short examples of limitations and modifications, which might be good to examine more in depth but some of them are extremely complicated to include in the models. Still, it is worth to note them to better understand what models do not necessarily tell us. Next, I present first more accessible modifications such fixed costs, agents' investment costs, nonnegativity constraints and charging

format, and then more complex issues such intra-group externalities, endogenous homing decisions, market power of agents are discussed and source of agent heterogeneity.

#### 4.1. More accessible modifications

The models consider only case, where platforms incur no fixed cost. Platforms incur only constant marginal cost of serving one more agent and  $AC = MC$ . Platforms typically need to be able to attract large number of agents and marginal costs of serving one extra agent are close to zero and relatively constant after having large number of agents in the platform. However, platforms may incur extremely high fixed cost in the early stage. Consider for example search engines and shopping malls. They need to build the platform in the beginning, and they incur massive fixed cost from that. This might be reasonable to consider at least if the models were extended to describe entry of new platforms. Cross-group externalities are also one factor which makes entry to such markets hard and strengthen the early mover advantage.

Agents may need to do some additional investment to enter platform. Retailers may need to set up a store in the shopping mall, businesses may need to optimize their website to exploit search engine advertisement and game developers may need to invest in some platform specific game developing skills. Armstrong (2006) points out in competitive bottlenecks model that, one could include this kind of investment cost within model but key outcome that there will be too few agents present on the multi-homing side won't change.

Armstrong (2006) points out that nonnegativity constraint is plausible to include in the models since inexistence of it may lead to serious adverse selection and moral hazard problems. This is quite straightforward, and such constraint is relatively simple to include. Armstrong and Wright (2007) include nonnegativity constraint to the models of competing platforms. Nonnegativity constraints are also industry specific question. Consider for example music, or other, festivals as platforms, musicians are interested in the number of listeners that festival is capable to attract, and listeners are also interested of course in the quality of musicians but also number of them. Musicians are subsidized group here; they are subsidized to attract listeners. Clearly, it doesn't make any sense to consider nonnegativity constraints in this context.

Armstrong (2006) consider access fees, per agent charges and their combination. Per agent charges are closely related with Rochet and Tirole (2003) per transaction charges and if platform commits to deliver constant utility per agent on the other side, then these two formats equal. Pure per transaction charges are not sufficient in every context, they apply well with credit card market and in online market places. When it comes to advertisement it is difficult to ensure has transaction happened due to the advertisement, or not. Online it may be possible to track clicks and user behavior but still it is not as clear in every two-sided market as in online market places and credit card markets. In traditional newspapers and magazines clicks, or interactions, are not possible to be detected. Format of costs are as well quite case specific. As Armstrong (2006) points out, it is always case specific question, which kind of set of charges and costs should be chosen in models.

#### 4.2. Complex issues

Intra-group externalities may arise in negative or positive form as well as cross-group externalities. If online marketplaces, such Amazon and Alibaba, are considered, intra-group externalities might be considered negative on the sellers' side. On the buyers' side, externalities might be considered negative if supply is assumed to be limited. In the context of video game platforms, one could consider to be positive intra-group externalities if there are network effects in consuming, namely playing

game. In the sense of online marketplaces, Armstrong (2006) considers only initial setting where agents are heterogenous enough on the seller side and do not compete against each other. In the sense of consumer side, models in Armstrong (2006) ignores possibility of limited supply and existence of network effects in consuming.

Short analysis by Armstrong (2006) suggests that effects of intra-group externalities on one side depend on the possibility to charge agents on the other side. For example, shopping malls usually do not charge consumers for access and then shopping mall need to do their profit from retailers. Then shopping mall benefits if it allows only retailers, who will have local monopoly, to join. Then consider platform, which is capable to charge consumer side, let's say that platform is magazine, which attracts both consumers and advertisers. Now Armstrong (2006) points out that, allowing advertiser competition is dominant strategy and this leads magazine to obtain all of its profit from consumers.

The models in Armstrong (2006) consider single-homing and multi-homing as exogenous. It is also possible, as Armstrong (2006) points out. that both sides multi-home to some extent if models account fixed benefit. Fixed benefit provided by both platforms may be one source of multi-homing. However, large fixed benefits provided by platforms may decrease the relevance of two-sided issues. If homing decisions are given as exogeneous, then models will apply to describe only settings where such behavior occurs. However, it is extremely difficult to completely understand which factors actually drive agents to multi-home or single-home on which sides of the platform. Still, it is useful to understand that exogenously determined homing decisions may limit applicability of the model. Armstrong and Wright (2007) examines exclusive contracts set by platforms to multi-homing agents as a source of endogenous single-homing. Platforms would have incentive to offer such deals for multi-homing agents if it allowed undermining competitive bottlenecks equilibrium and then its rival platform. These kinds of deals would make agents, who in the first place multi-homed, better off at the expense of agents, who in the first place single-homed.

Armstrong and Wright (2007) section 4 considers different combinations of differentiation parameters in the context where agents can obtain fixed benefit only from one platform regardless of multi-homing. When in the Single-homing model differentiation parameters were assumed to be large enough compared to gross-group externalities, they consider in particular case, where product differentiation is high on one side and low on the other side. Model considers different possible outcomes and come to result that similar kind of outcome as in the competitive bottleneck model may arise endogenously.

It would be interesting to try to address question how platforms decide the degree of product differentiation on both sides. However, it is reasonable to assume that Hotelling specification's covered market assumption holds if some symmetric equilibria are wanted to be described.

In Monopoly and Single-homing model, agent heterogeneity is addressed by varying fixed benefit. On the contrary, multi-homing model addresses agent heterogeneity by varying cross-group externalities on agent basis. It may depend on the context, which source of agent heterogeneity is more appropriate. Also, when endogenous single-homing is wanted to address by introducing exclusive contracts set by platforms, Armstrong and Wright (2007) note that analysis turn complex if fixed benefits are included.

The competitive bottlenecks model builds on the assumptions that multi-homing side agents' decisions to join platforms are independent and therefore there is none competition of these multi-homing agents between platforms. To work, model certainly requires this assumption. It may be more plausible assumption in some cases than others. However, if there was concern that some agents on the multi-homing side have relatively big market power to attract agents from the single-homing side

compared to others, then results of the model should be examined critically and with extra care. Relaxing this assumption might require completely different modelling. To address this question, it is also needed to address such agents' ability to bypass platform completely in order to reach agents on the other of the platform. Examples of such two-sided markets, where this assumption might be needed to consider carefully are for example trade fairs, social gatherings and music festivals.

## 5. Competition policy

To understand essential characteristics of two-sided markets from competition policy point of view, definition of competition policy is needed. Motta (2004, p.30) provides one definition from economics angle: *"The set of policies and laws which ensure that competition in the marketplace is not restricted in such a way as to reduce economic welfare"*.

This definition is quite abstract but emphasizes that from economics standpoint it is possible to consider economic efficiency as the ultimate objective of competition policy and leave other objectives of competition policy for consideration of policy makers. Economic welfare means total surplus which constitutes from consumer surplus and producer surplus. It is not clear that how distribution of total surplus between consumers and firms should be addressed in competition policy. Also, question regarding which one of the two, total welfare or consumer welfare, should be the main objective of competition policy is complicated and there are good arguments on the side of consumer welfare, but total welfare is more often considered as more appropriate objective by economists (Motta, 2004).

Armstrong (2006) points out that: *"Unless they act to tip the industry to monopoly, positive cross-group externalities act to intensify competition and reduce platform profit"*. Rysman (2009) similarly points out that presence of network effects tends to affect in such a way that two-sided markets are likely to tip toward a single dominant platform. Of course, it may be that monopoly platform is more desired than few competing platforms, when social welfare is considered, but then careful consideration should be given at how some platform has been able to reach such position. In this sense, it would be valuable in this chapter to consider exclusionary practices which are practices exercised to deter entry of rivals or forcing them to exit. Motta (2004) divides exclusionary practices to pricing and non-pricing strategies. As non-pricing strategies he mentions over-investment, tying, bundling, incompatibility choices, exclusive dealing and refusal to supply. Predatory pricing is "pricing strategy" of exclusionary practices.

Antitrust issues addressed by competition policy in EU can be divided on prohibition of anti-competitive agreements, stated in Article 101 of the Treaty on the Functioning of the European Union (TEFU), and prohibition of abuse of dominant position, stated in Article 102 TEFU. Article 101 prohibits anti-competitive agreements between independent market operators, and it covers both horizontal agreements and vertical agreements. Horizontal agreements refer to agreements at the same level of supply chain between actual or potential competitors. If we considered horizontal agreements in the context of two-sided markets, they involve at least agreements between competing platforms. Vertical agreements refer to agreements between parties at different levels of supply chain. (Antitrust procedure in anticompetitive agreement; Antitrust procedures in abuse of dominance, EC, 2013)

Motta (2004) notes that exclusive dealing belongs to vertical agreements category and that it does not necessarily require dominant position by firms exercising such deals, but they may involve the fact that firm using them is dominant.

This chapter continues to discuss assessment of dominance, predatory pricing and exclusive dealing in the context of two-sided markets. However, there are also other types of practices, which can be



used to reach the same objective as exclusive dealing, but they are not discussed any more detail in this thesis. Crémer, de Montjoye, and Schweitzer (2019) point out in the context of digital platforms, that platforms rarely directly forbid multi-homing by their users and similar outcomes as with exclusive dealing may be reached through fidelity rebates, bundling and technical means. For example, they note that certain type of criteria taken into account by ranking algorithms or recommendation systems can incentivize agents to single-home instead of multi-homing.

## 5.1. Dominant position

Being in dominant position in some market is not illegal itself but firms in dominant position have a special responsibility to ensure that their conduct is not anticompetitive. European Commission starts assessment of dominance by defining the relevant market and this is divided to two aspects product market and geographic market. In terms of product market essential is that do consumers consider products or services as substitutes to each other and in terms of geographic relevant is that in that area the conditions of competition for a given product are homogenous. Market shares can act as indicators of initial dominance and EC notes that firms with less than 40 % market share are unlikely to be dominant. (Antitrust procedures in abuse of dominance, EC, 2013)

Assessment of dominance might not be as straightforward in two-sided markets as it is in the traditional one-sided markets. Giving all else equal, two-sidedness limits market power in that sense that price increase in one side affect both sides (Evans & Noel 2005). Price changes on either side affect both sides because value that platform is able to offer for one side relies on the number of users on the other side. If some fraction of users decides to leave platform due to price increase on one side it has effect on users on the other side, whose decisions again affect to the other side. According to Evans and Noel (2005) this indicates that actual price sensitivity in platform is higher than ordinary price elasticity on one side however they also note that these feedback loop effects may not occur instantly. It is needed to emphasize that Armstrong (2006) showed that while cross-group externalities have this kind of profit reducing nature, firms may choose a charging format, which aims to cut those cross-group externalities. In addition, relevance of these kind of feedback effects depends on the nature of two-sided markets because sometimes cross-group externalities are not positive to both directions within platform. For example, consider advertised supported media such newspapers or TV broadcasts, if price is increased on the advertisers side and as result number of advertisers on the platform is decreased, effects to customers are quite minimal compared to two-sided markets such shopping malls or online marketplaces, where this cross-group externality from retailers' side to customers may be positive to both directions. Even though, there might not be such positive feedback effects in advertised-supported media, if advertisers' price is increased, it doesn't mean that such price increases couldn't have effects on economic welfare. Evans and Noel (2005) also note that while two-sides are present, competition already on one side of the platform reduces platform's ability to make profits by excessive pricing. However, they also note that multi-homing on one side makes it possible for platform to make higher profits since multi-homing reduces the intensity of competition on that side as we saw in Armstrong (2006).

Pricing in two-sided markets differs from traditional one-sided markets and no traditional tool, such price-cost margin, should be used as indicators of market power exploitation on one side of the platform (Evans & Noel 2005). Furthermore, they emphasize problems of market definition in the context of two-sided market by pointing out that platforms face competition not only by other platforms but by one-sided market operators as well. In addition, they note that, platforms may face competition on both sides by some rival platforms and only on one side by some other platforms.

As I noted earlier, Lerner index was developed to describe the size of monopoly power. Traditional Lerner formula receives values between as following  $L \in ]0; 1[$ . Near zero indicates no monopoly

power since it requires that price equals to marginal cost. The higher the Lerner index for a given firm the higher is the monopoly power of that firm. Lerner index describes relation between price marginal cost margin and inverse elasticity of demand. This relation can be thought via noting that, when profit is maximized, marginal revenue equals to marginal cost, but for monopoly, which faces down sloping demand curve, price doesn't equal to marginal revenue and elasticity of demand and price-marginal cost margin have negative relation.

Armstrong (2006) uses modified Lerner index (7) in the monopoly model and its crucial difference to traditional Lerner formula on one-sided markets is that it accounts also cross-group externalities. Here, Lerner index acts as price-cost margin since  $f_1$  is constant while no fixed cost are assumed to exist. If that formula (7) was used to determine degree of monopoly power of platform then no monopoly power would mean that  $p_1 = [f_1 - \alpha_2 \phi_2(u_2)]$ . This makes sense because this is economic welfare maximizing price as in (3). High degree of monopoly power would mean that  $[f_1 - \alpha_2 \phi_2(u_2)]$  is zero. This leads to outcome, where modified Lerner equals one. Then the price would be positive and above the cost. Factor might be negative as well and then this modified Lerner index could get even larger values than 1. It is the presence of cross-group externalities  $\alpha_2 \phi_2(u_2)$ , which explains this. Rochet and Tirole (2006) clarify that it is not marginal cost, that is included in Lerner formula in the context of two-sided markets, but opportunity cost.

Weyl (2010) develops a general measure of market power in the context of monopoly in two-sided markets, see equation 6 in Weyl (2010). This modification of Lerner index is more complex compared to presented by Armstrong (2006). Model presented by Weyl (2010) is more general in few ways, first, it manages to relax the assumption that all the agents in one group values additional agent in other group to the same extent. It also considers platform not to choose prices, but to choose participation rates of two groups of agents. Modified Lerner presented by Weyl (2010) replaces MC in (5) by fixed cost of letting agent to join platform, fixed cost of agent's interaction within platform and a factor which differs from  $\alpha_2 \phi_2(u_2)$ . The difference lays in that, platform manages only partly extract benefit from group 2, provided by an additional group 1 agent. Weyl (2010) states that parameter replacing  $\alpha_2$  is called average interaction value of marginal users. This is not possible to describe in setting as in Armstrong (2006), where assumption about homogeneity of agents' valuation regarding agents in the other group holds.

Even though general model provided by Weyl (2010) is too much to examine in this thesis, interestingly it claims that this modified Lerner index can be used to measure market power and predation in two-sided markets. Even more, Weyl (2010) suggests that aggregate Lerner index can be formed by weighting two sides of platform by their participation. If these parameters were possible to estimate, then this general measurement could be used to examine monopoly power of platforms.

When digital two-sided platforms are considered, Crémer et.al, (2019 p. 50) note that cross-group externalities are not the only factor to account. They point out that analyses about data issues is much importance as well, which makes analyses even more complex and it is quite open question how dominance should be assessed in such two-sided markets. Even more, they suggest that, at least no single parameter alone should be used for assessment and analyses are needed to do on case by case basis.

## 5.2. Predatory pricing

In all three models, cross-group externalities tend to affect platforms' choices in a way that it is possible that platforms subsidize one group to the extent that price set for them is below marginal cost of serving that group or for monopoly even zero. Here is needed to remember that in model platforms were assumed to incur constant marginal cost. This requires that there are no fixed costs.

In monopoly model, this happened when one group's elasticity of participation was large simultaneously with positive cross-group externality to another group or if that cross-group externality alone was large enough. In some cases, platforms would optimally set price even negative. In Single-homing model, the side, which was more competitive and raised higher externalities to other side, was offered lower prices. Especially, when large positive externality to one direction, negative externality to other direction, low differentiator parameter on the side, which raised positive externalities, existed and equation (12) held, price was set below marginal cost. How close to zero price can be on one side, depends on the size of per agent costs. In competitive bottlenecks model, in both cases, with access fee and per agent charges, it was possible that price for single-homing group agents was set to 0 or even below.

If firms in one-sided markets would act like this and charge not only below marginal cost but even negative prices, it would be most likely considered as predatory pricing. Motta (2004) defines predatory pricing as practice to set prices to profits sacrificing level in the short run in order to drive rivals out of the market and get higher profits in the long-run. Usually low prices for consumers are considered good thing but in case of predatory pricing there will be welfare loss in the long-run since competition is reduced. Assessment of predatory pricing needs to be done cautiously because incentives for price competition are not wanted to be sacrifice (Motta, 2004).

So, predatory pricing refers to case, where firm sets prices so low that it will experience short term losses with intention to acquire its competitors share of market to lift prices higher up after predatory. However, Commission (2009, paragraph 71) indicates that Commission do not require dominant undertaking's ability and likeliness to increase prices above the level that was in the market in the first place as a necessary condition for intervention.

As noted earlier, Evans and Noel (2005) consider that price cost margins on one side of the platform should not be used as an indicator of market power whereas Weyl (2010) introduces modified Lerner index, which can account also presence of cross-group externalities, and suggests that this can be used not only for measuring market power but also to access predatory behavior.

Cr  mer et.al (2019) point out that while in many industries introducing new products with low price and increasing price afterwards once consumers are convinced of the product's quality may be general practice, in two-sided markets presence of cross-group externalities reinforce this kind of behavior. This makes it difficult address the difference between natural market entry strategy and predatory pricing.

### 5.3. Exclusive dealing

Armstrong (2006) touches upon two kinds of forms of exclusionary dealing. First, while models do not contain any intra-group externalities, they do not account any intra-group competition either. In this sense, agents within their group are therefore in monopoly position. One possible explanation for this might be that platform makes such exclusive deal with agents that it commits to totally restrict agents' rivals' entry to same platform. Armstrong (2006) points out that this may occur for example in shopping malls and advertised supported TV. In shopping malls, retailers may be willing to pay higher price if they receive local monopoly in the shopping mall. In TV, advertisers may be willing to pay higher price for advertisement if their rivals' advertisement is not shown in the same slot.

Second, single-homing is exogenous within models and as pointed out exclusive dealing might help to understand single-homing in endogenous way. This can be understood in context, where such exclusive dealing takes place that agent commits to join only single platform. The incentive for

platform to offer such deals is possibility of foreclosing its rival platform. Rest of this chapter focuses to this kind of exclusive dealing.

Armstrong and Wright (2007) consider exclusive contracts as a source of single-homing. They analyze exclusive contracts in context of pure network effects, where utility is determined only by cross-group externalities and platforms do not differentiate.

Analyses is easier in this kind of context, since platforms have possibility to foreclose their rival fully and therefore incentive to conduct such contracts. If fixed benefit is included and product differentiation is high on the single-homing side, it may well be that exclusive contracts lead only to partial foreclosure, where agents only on the side of exclusive dealing decide all to join one single platform (Armstrong & Wright, 2007). Analysis of partial foreclosure, which may be more feasible assumption in some contexts turns out complex (Armstrong & Wright, 2007). They show, that exclusive dealing in the context of pure network effects change how the total surplus is shared between two groups of agents and platform quite detrimentally. Their analyses suggests that multi-homing side agents, which sign up exclusive contract with platform will be now much better off. Agents on the side, which single-homed already in the first place and benefitted from that are now clearly worse off.

Lee (2013) examines exclusive contracts in the context of US video game industry in 2000-2005, when 60 % of all software titles were exclusive to one of three platforms. Lee (2013) suggest that everything else held equal, absence of exclusive contracts between software developers and gaming platforms would have increased total hardware adoption by 7 percent and software adoption by 58 percent, increasing consumer welfare approximately 1,5 billion dollars. This seem to be in line with results of how surplus is shared between participants of modelling by Armstrong and Wright (2007). However, as Lee (2013) notes, analyses do not account possibility that prohibiting of exclusive contracts between gaming platforms and software developers would leave video game industry more concentrated or reduce investment incentives leading to increase in price or decreased quality of software.

## 6. Conclusions

Two-sided markets are special because both platform governing groups' interaction and cross-group externalities are present at the same time. Platforms face complex decisions regarding pricing, where they need to account that their decisions on one side of the platform have effects on their success on the other side of the platform. Armstrong (2006) suggested that there are three key factors determining market outcomes i) relative size of cross-group externalities, ii) charging format and iii) agents homing decisions, whether they choose to single-home or to multi-home. Models clearly described these three factors' effects on market outcomes. The competitive bottleneck model combined all these factors and suggested that multi-homing side is exploited to attract agents on the single-homing side. Format of charges affected with the sign of cross-group externalities to how much single-homing agents were subsidized given the level of product differentiation on that side. Even though presented models describe characteristics of two-sided markets well, there are some limitations, which mean that models do not apply to all two-sided markets equally well.

First set of limitations are easier to overcome by modifying models. Such modifications are related for example to determining of utility within model. In some cases, it would be worth of assessing in more detail how accounting presence of intra-group externalities or fixed benefit would affect the outcomes. Adding intra-group externalities are certainly more complex than 'base' utility. Also, it is useful to be aware that format of charges and costs depend on the context. Per agent charges may be more applicable in some contexts than access fees and per agent costs incurred by platform may apply

better in some contexts than costs per transaction. Nonnegativity constraint on prices may be sufficient to include in many cases but not necessarily in all. Furthermore, it is good to remember that setting up a platform requires often large investment in the beginning, and this has effects also on the attractiveness of market entry as well as gross-group externalities.

More complex questions arise when sources of agents' homing decisions and platforms differentiation decisions are considered. These are much harder topics to answer or to model, but it is useful to keep them in mind when two-sided markets are examined. Armstrong and Wright (2007) addressed these questions partially by presenting model, where platforms have different degree of product differentiation on two sides, and by considering exclusive contracts as a source of single-homing in a setting, where agents were multi-homing. Another complex question is that how market power of some agent on the multi-homing side would affect the outcomes of the model. If such agent existed, then platforms of course would like to have that agent on their platform and possibly ignore the other platform. Competitive bottleneck builds on assumption that no agent on the multi-homing side have such market power. This is also case specific question and not necessarily valid in most two-sided markets but in some cases, when there are relatively less agents in the other group doing decisions whether to join platform(s) or not, this might be needed to account.

When social welfare is considered it is not clear that is competition between platforms desired or would single platform provide greater social welfare. Therefore, it seems appropriate address also questionable strategies to reach such position. In case of monopoly platform Weyl (2010) suggested modified Lerner formula to determine the degree of monopoly power and to assess predatory pricing in two-sided markets. Evans and Noel (2005) pointed out that two-sided markets should be considered in every time by accounting both sides when assessing dominance or predatory and that platforms may face competition not only from other platforms but also from one-sided market operators. When digital platforms are considered, Crémer et.al, (2019) suggested that no single parameter should be used for assessment and that it is relatively open question still, how dominance should be addressed in the context of digital platforms. About predatory pricing Crémer et.al, (2019) pointed out that presence of cross-group externalities in two-sided markets makes it even more difficult to assess difference between natural market entry strategies and predatory.

Exclusive dealing in two-sided markets can act as a source of single-homing decisions by agents, who multi-home. In this context Armstrong and Wright (2007) noted that analyses are simpler in context of pure network effects and minimal product differentiation between platforms allowing full foreclosure of rival platform. Armstrong and Wright (2007) suggested that agents on side, which single-homed already in the beginning, will suffer from exclusive contracts and agents, who sign up exclusive contracts with platform will gain. This was supported by empirical results of Lee (2013) although results didn't account effects of market concentration fully.

It seems that it is still not completely clear that how relevant two-sided issues really are in every context. It is not possible to develop perfect model, which accounts every detail of two-sided markets, but still further research may open new angles to this difficult topic. It could be valuable to examine in more detail, where the difference between analyses of two-sided markets and one-sided markets lays, when cross-group externalities are not positive to both directions or fixed benefit and intra-group externalities are present as well. However, it may be difficult to address the size of different sources of agent utility and their relation. There are quite many critical assumptions in models describing two-sided markets. Different sets of assumptions seem to fit better to describe some specific settings. Question about source of agent heterogeneity related to ways determine utility in models seem to bear many implications for other factors as endogeneity of homing decision. This area seems most prominent area for me to look more answers to the question what two-sided markets actually are.

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